Space Weather Technical Forecast

Issued on Friday 11 October 2024 at 13:05 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Very gradually waning CME effects in course. Decreasing likelihood of G2/3, S-scale events now less likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity at GOES16 and 18 has been Moderate, with the peak flare in the period an M3.0 from the now-departed Ex-AR3842 on the southwestern limb.

There are now six numbered sunspot regions on the visible disc. There are three main areas of the disc that currently harbour sunspot regions: the northwest, which retains AR3848 as a Dhi/Beta, with some consolidation evident in recent hours its its previously well-dispersed trailing spots and pores.

Near centre disc, AR3849 showed fading of minor northern spots as further ones developed to its south - these may yet be re-designated as a small new bipolar region. Finally, the southeast disc kept its two main groups. AR3852 showed minor development of small spots around its main penumbral leader, however the strong growth trend continued in its immediate northern neighbour, AR3854, which showed areal growth, proliferation of central spots and spreading.

No further Earth-directed CMEs have been observed. A large filament in the northwest-central disc is for the moment stable but is being monitored given its location.

Solar Wind / Geomagnetic Activity: This 24-hour period initially showed the tail of CH78 influence, perhaps with vestigial CME remnants from the activity earlier in the UTC working week.

This near-slow regime was very abruptly replaced at L1 (ACE) by the awaited X1.8 09 October CME at 10/1448UTC. This event was presaged on the MAG instrument of STEREO A from 1206UTC, with the CME here evolving to an IMF of 57nT and Bz of -52nT within 90 minutes of onset. This gave a proxy of roughly 2.5 hours' warning for conditions at Earth (STEREO is at 0.96AU and leads Earth by 25 degrees). Notably, the shock aspect was very well replicated at Earth downwind, but not the magnetic cloud - perhaps because STEREO is on the periphery of this event.

The CME hit Earth-based magnetometers at 10/1515UTC, whereupon BGS Hartland recorded a sudden impulse in its H-component of 75.6nT in one minute. For reference, the 10 May 2024 event was 223nT in two minutes here.

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The solar wind speed, recorded at L1 by DSCOVR and ACE started near 400km/s but rose as high as 810km/s just before 10/1500UTC. A gradual waning trend then ensued before a late resurgence to within the 700s of km/s into the current UTC morning. The solar wind density was very erratic, but peaked near 20ppcc during the CME shock around 10/1700UTC. A later peak around 11/1000UTC is thought to be due to DSCOVR's long-term higher measurement tendency (versus ACE).

The IMF was initially at Background but showed a slight ramp immediately prior to the CME. Once arrived, the CME shock reached IMF values of 40nT at 10/1627UTC. The CME signature evolved into a magnetic cloud at 10/2200UTC (with a temperature decrease observed at L1) and the IMF jumped further to 46nT and a perfectly anti-aligned -46nT Bz component (being negative but smaller in magnitude prior to this). This strong anti-alignment then continued for much of the remainder of the reporting period, very gradually waning in intensity. The IMF did not rotate significantly away from opposition until after 11/0900UTC, and even then only temporarily.

The phi angle was erratic but mainly away from the Sun (positive) in the slow regime and CME shock, but displayed a gradual sweep within negative territory after 11/2200UTC in the magnetic cloud.

Resulting geomagnetic activity was very disturbed through this reporting period. Initially Unsettled, four straight periods of Kp8 were then observed from 10/1500UTC (a Kp '9-' was erroneously assigned as a G5 in an alert for 10/2100-2400UTC - the correct scale value is G4). A slight waning has since been observed into the current UTC day.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 has continued its response to the X1.8 flare on 09 October. 10MeV started the period at 770pfu (S2) and rose in the snowplough-effect ahead of the inbound CME to a peak of 1810pfu at 10/1515UTC (S3) before waning - a trend that accelerated after the magnetic cloud's onset. Levels and have since shown a very gradual downward trend to finish near 3pfu (i.e. sub-S1).

High energy electron flux (greater than 2MeV) observed by GOES16 rose within Moderate levels prior to the CME arrival, perhaps as part of the diurnal cycle. This peaked at 937pfu at 10/1500UTC before the CME arrived and resolutely suppressed electrons to Normal Background at GEO.

The associated 24-hour fluence was below the Active threshold. The 24-hour fluence values have been restored, with a 11/0300UTC value of 9.4e6 on a slight falling trend.

Four-Day Space Weather Forecast Summary

Solar Activity: R1s remain Likely through this four-day period given developments on the disc, their complexity, and up to four arrivals over the eastern limb to round out the current UTC working week. The trend is level throughout - pending assessment of arriving regions, with none departing.

Solar Wind / Geomagnetic Activity: The CME from the 09 October X1.8 flare and filament eruption is continuing to affect Earth, but its intensity continues to wane. This is the only CME in

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the forecast. Either of a pair of potential coronal hole fast winds may affect Earth late day 3 (Sunday 13 October), although confidence in their effects being felt is low.

Initial G3 conditions remain possible but should continue to ease though day 1 (Friday 11 October) as the CME effects wane. G1 Minor (Kp 5) intervals may feature early day 2 (Saturday 12 October), but should wane further as the weekend progresses. Quiet-Active (Kp 1-4) activity is then expected days 3 and 4 (13-14) with a low confidence Slight Chance of G1 should either of the coronal holes' fast winds impinge on Earth.

Energetic Particles / Solar Radiation: The risk of S1/Minor storms should return to the residual risk for the disc by day 3 (Sunday 13 October). This accounts for the initial raised levels and the presence of Ex-AR3842 over the limb. East limb arrivals do not feature.

High energy electron flux is now at Normal Background. A rising Slight Chance of recovery of fluence may occur later in the UTC weekend, before any possible fast winds arrive, although the effect of these should be limited.

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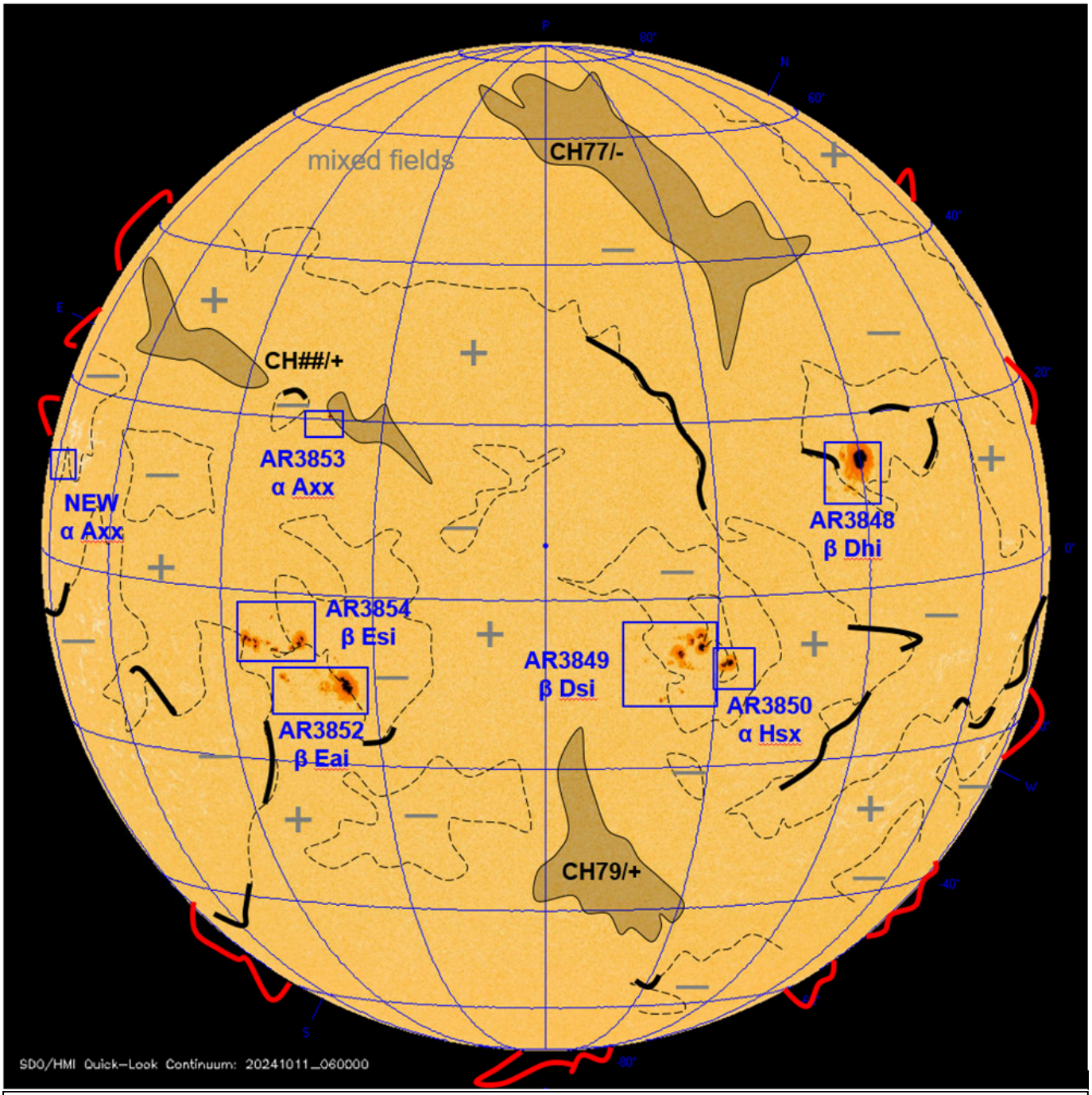
Figure 1: MOSWOC solar synoptic map, validity time 11/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

The CME from the 09 October X1.8 flare and filament eruption is continuing to affect Earth, but its intensity continues to wane. This is the only CME in the forecast.

Either of a pair of potential coronal hole fast winds may affect Earth late day 3 (Sunday 13 October), although confidence in their effects being felt is low. Earth may potentially 'thread the needle' between these northern and southern hemisphere features. CH79/+ in the south has retreated pole-ward compared to last rotation and appears more tenuous, and therefore any connection with Earth is likely to be weak, with any fast wind approaching 450km/s. Alternatively, CH77/- also stands a chance of connecting around the same time, however its apparent greater intensity (versus CH79/+ from e.g. AIA211 imagery) will be mitigated against by its unfavoured polarity.

Initial G3 conditions remain possible but should continue to ease though day 1 (Friday 11 October) as the CME effects wane. G1 Minor (Kp 5) intervals may feature early day 2 (Saturday 12 October), but should wane further as the weekend progresses. Quiet-Active (Kp 1-4) activity is then expected days 3 and 4 (13-14) with a low confidence Slight Chance of G1 should either of the coronal holes' fast winds impinge on Earth into the new working week.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	90	50	5	5
Strong	**G3**	Yes	50	5	1	1
Severe	**G4**	Yes	20	1	1	1
Extreme	**G5**	No	1	1	1	1

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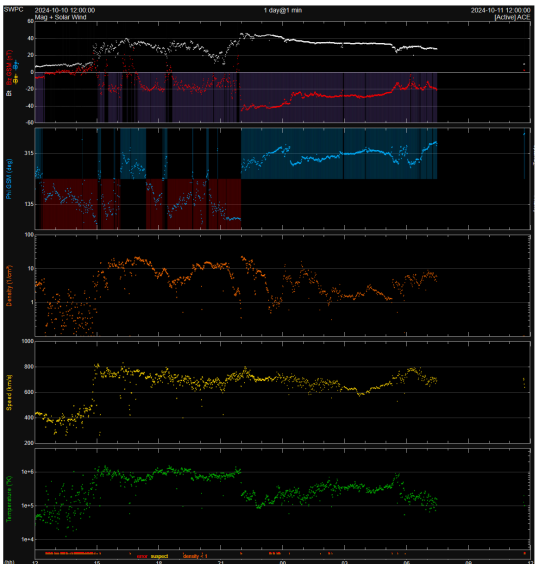
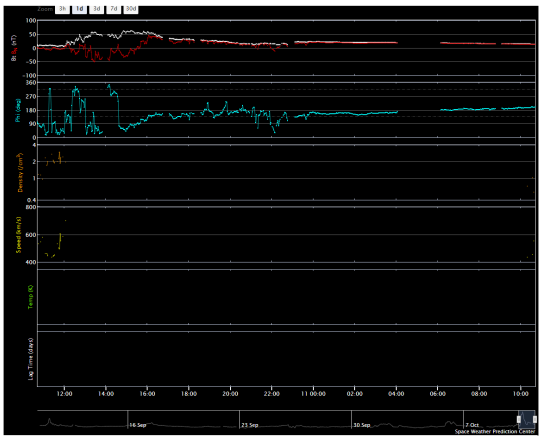
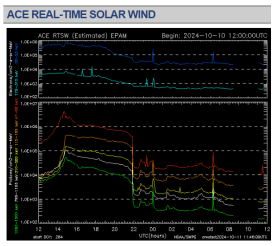
Figure 2: NOAA SWPC metrics for CME arrival over last 24 hours. From left to right: L1 solar wind parameters at ACE and DSCOVR showing a shock from 10/1448UTC and cloud from 10/2200UTC; compare with STEREO A MAG measurements (which start similar but diverge from 10/2200UTC, with STEREO's magnetic field environment strongly co-aligned with Earth's field by this time). On the right, ACE EPAM LEMS measurements show the sharp increase or ramp of low energy protons immediately prior to the CME's arrival here.







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Radio Blackouts - X-Ray Flares

The recent very active sunspot region Ex-AR3842 is now on the far side, however no further front-sided regions depart over the western limb in the four days. Going some way towards potentially mitigating against the loss of Ex-AR3842, the Carrington locations for up to four returning regions are due over the eastern solar horizon inside 24 hours' time,

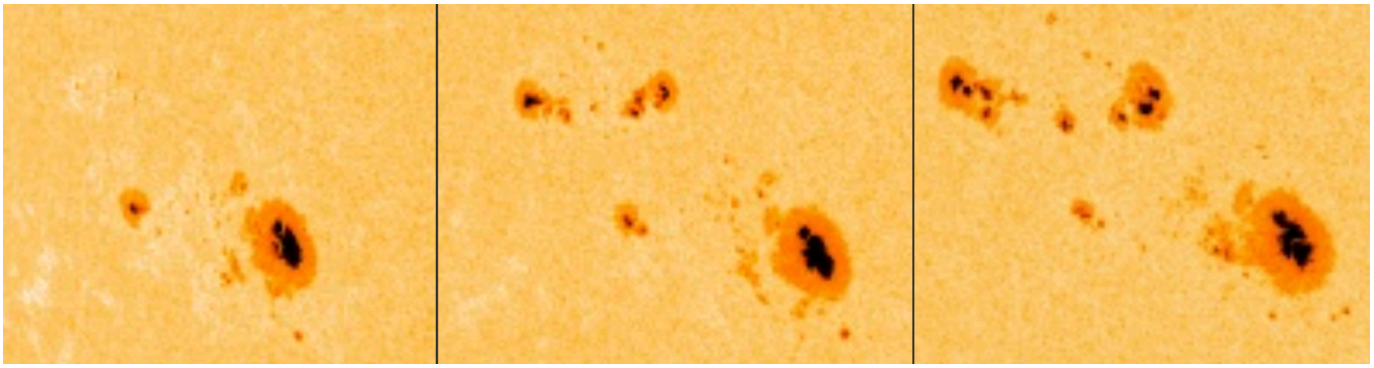
Added to these populating/depopulating factors is the consideration of a recently emerging sunspot region in the eastern hemisphere in the form of AR3854, which continues to show strong growth and is one to watch as it approaches centre-disc (for CMEs).

All considered, the risks of further significant flares are now lower than in the recent past (when Ex-AR3842 was present as a front-sided feature). The risk sources for further flares are now much more well-spread across the disc: AR3848 has the history of such activity in the northwest; AR3849 is decaying (but is in a prone location for CMEs); and the southeastern AR3854 is showing a growth trend.

The significant flare risk level is therefore almost flat - after an initial slightly higher risk from Ex-AR3842 should it produce any very large events from near 110W.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	65	60	60	60
Very Active	R3-R5 (X Class)	No	15	10	10	10

Figure 3: Growth of AR3854 (upper region) in HMIIF sequence valid at 1115UTC on 09, 10 and 11 October (i.e. 24-hour intervals). Also shown is the much less-changed AR3852 below.



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Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 has been above background in the wake of the combined X1.8 and filament eruption on 09 Oct from the vicinity of AR3848 in the northwestern quadrant. This showed a relatively hard spectral response, however 50MeV and 100MeV traces have now returned to resting background as of the current UTC day.

As expected, the 10MeV response has proven much more sustained, and rose from S2 to S3 during the UTC afternoon of Thursday 10 October as the inbound CME swept up protons in the interplanetary environment. Proton levels peaked as the CME shock arrived around 10/1500UTC, gradually falling through S2 in the ensuing hours, and further still to S1 as the shock evolved to the magnetic cloud proper at the end of the UTC day.

The risks of S-scale remain higher than raw values due to the ongoing slightly raised levels. Regarding potential new enhancements, AR3848 remains on the disc, and account must still be taken of AR3842's gradual retreat around the far side near 110W.

Overall, there remains a Chance of a return to S1 at first, relaxing to the residual risk for the current disc later in the coming UTC weekend as the counts in the near-Earth environment subside and Ex-AR3842 rotates sufficiently far round as to no longer pose a significant threat.

Radiation Storms	**Level** ($cm^{-2}sr^{-1}s^{-1}$)	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	Yes	40	25	20	20
Very Active	**≥ S3 ***	Yes	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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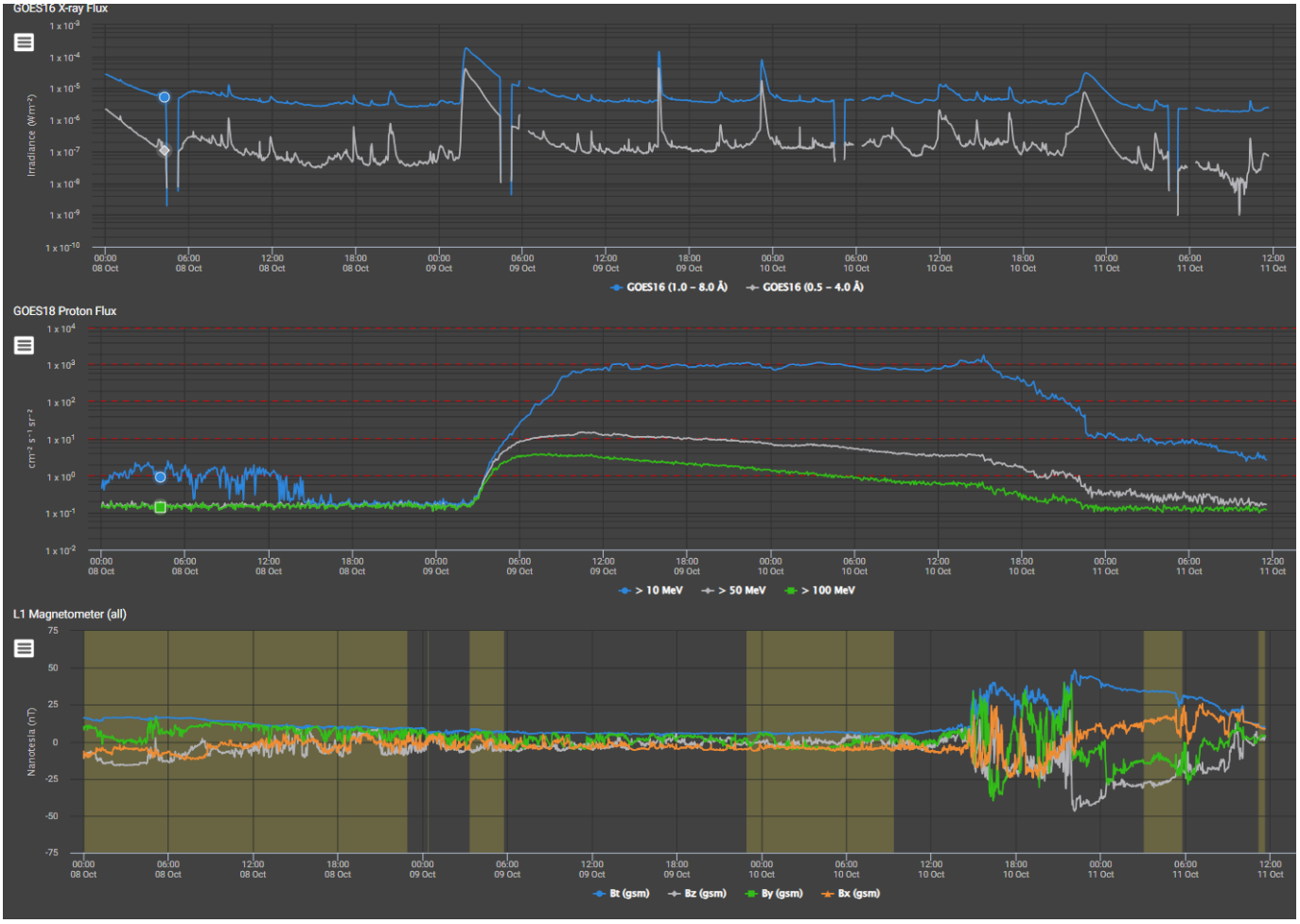
Figure 4: GOES16 X-ray flux (top) and resultant GOES18 high energy proton flux (middle). Note the ongoing response to the 09 October CME, only attenuated by this arriving at Earth (see L1 magnetometer trace at ACE below). Note the character of the decline changes after the magnetic cloud onset at 10/2200UTC, which was coincidentally the time of a large, unrelated X-ray flare.



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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) is currently at Normal Background levels after the 09 October CME arrival during the second half of 10 October. The timing of the arrival was such that it was almost concurrent with the typical local peak in the diurnal oscillation at GOES16, although this was soon attenuated as the CME compressed the outer Van Allen belt beyond GEO. These low counts at GEO are likely to continue on 11 and perhaps 12 October. A gradual recovery to diurnal Moderate or High is possible through 13 October before any fast wind from CH79/+ (or perhaps CH77/-) takes effect, should either arrive.

There is a rising Slight Chance of Active 24-hour integrated fluence, probably peaking later in the UTC weekend given the forecast described above. MOSWOC REFM is not considered useful in this situation given the utter dominance of a large CME early in its evolution, and then the expected dissimilarity of the coronal holes' fast winds on this pass.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	10	20	20
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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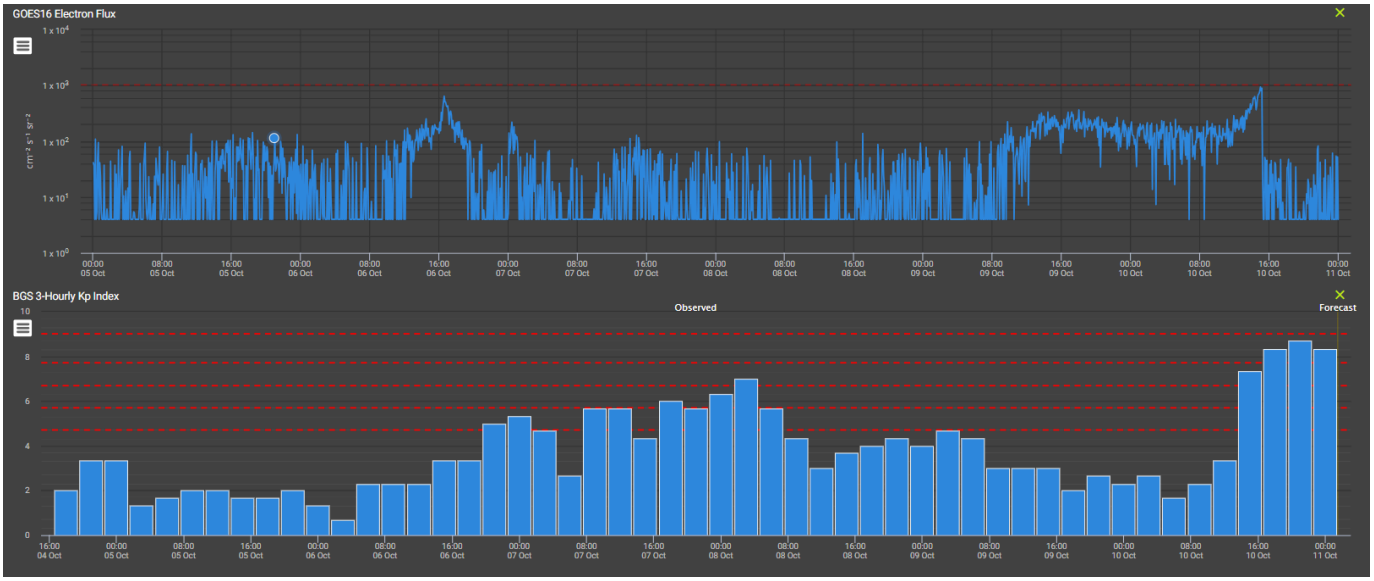
Figure 5: GOES16 greater than 2MeV electron counts for the period 04-10 October inclusive showing the reaction at GEO to increased geomagnetic activity on 06 and especially 10 October (BGS Kp indices shown below). A gradual restoration of Moderate, perhaps diurnally High flux can be expected over the coming UTC weekend - as shown at times in this period.



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